

CLAIMS

1. An integrated process for the conversion of feedstocks containing coal into liquid products by the joint use of at least the following seven process units: coal
5 liquefaction (CL), flash or distillation of the product obtained from the liquefaction (F), extraction with a solvent to remove the ashes (SDAsh), distillation to separate the solvent (RS), hydroconversion with catalysts in slurry phase (HT), distillation or
10 flash of the product obtained from the hydroconversion (D), deasphalting with a solvent (SDA), characterized in that it comprises the following steps:

• sending the feedstock containing coal to one or more
15 direct coal liquefaction steps (CL) in the presence of a suitable hydrogenation catalyst;

• sending the stream containing the product obtained from the coal liquefaction reaction to one or more
20 flash or distillation steps (F) obtaining a gaseous stream and a liquid stream;

• sending the liquid stream to an extraction step with a solvent (SDAsh) whereby an insoluble stream is obtained, consisting of the mineral matter present in the feedstock and non-reacted coal and a liquid stream
25 consisting of the liquefied coal obtained and the sol-

vent used;

- sending the liquid stream consisting of the liquefied coal and the solvent used to one or more distillation steps in order to substantially separate the solvent contained in the liquid stream, which is recycled to the extraction step with a solvent (SDash);

- mixing the liquid stream substantially consisting of the liquefied coal and at least part of the stream containing asphaltenes obtained in the deasphalting unit with a suitable hydrogenation catalyst and sending the mixture obtained to a hydro-treatment reactor (HT) introducing hydrogen or a mixture of hydrogen and H_2S therein;

- sending the stream containing the reaction product of the hydro-treatment and the catalyst in dispersed phase to one or more distillation or flash steps (D) whereby the different fractions coming from the hydro-treatment reaction are separated;

- sending at least part of the distillation residue (tar) or liquid leaving the flash unit, containing the catalyst in dispersed phase, rich in metal sulphides produced by the demetallation of the feedstock and optionally coke, to the deasphalting zone (SDA) in the presence of solvents, optionally also fed by at least one fraction of the liquid stream substantially con-

sisting of the liquefied coal, obtaining two streams, one consisting of deasphalted oil (DAO), the other containing asphaltenes.

2. The process according to claim 1, wherein the feed-
5 stock containing coal essentially consists of coal.

3. The process according to claim 1, wherein the suitable hydrogenation catalyst present in the liquefaction step (CL) is at least partially recovered from the units downstream of said step.

10 4. The process according to claim 2, wherein the feed-stock essentially consisting of coal is slurried in a hydrocarbon matrix.

5. The process according to claim 4, wherein the hydrocarbon matrix comes from the units downstream of the
15 liquefaction step (CL).

6. The process according to claim 5, wherein the hydrocarbon matrix is part of the stream containing asphaltenes, as well as the dispersed catalyst used in the hydro-treatment step (HT), obtained in the deasphalting step (SDA) and/or part of the stream consisting of
20 deasphalted oil (DAO) obtained in the deasphalting step (SDA).

7. The process according to claim 1, wherein the direct liquefaction of the stream containing coal is effected
25 by mixing said stream with an aromatic solvent in a

quantity ranging from 20 to 80% with respect to the coal, and with a suitable catalyst in dispersed phase, operating at a temperature ranging from 360 to 440°C, at a hydrogen pressure ranging from 3 to 30 MPa and with residence times lower than or equal to 4 h.

8. The process according to claim 1, wherein part of the stream containing asphaltenes, as well as the catalyst used in the hydro-treatment step (HT), obtained in the deasphalting step (SDA) is added to the feedstock containing coal to be sent to the liquefaction unit (CL) as solvent.

9. The process according to claim 1, wherein part of the stream consisting of deasphalted oil (DAO) obtained in the deasphalting step (SDA) is added to the feedstock containing coal to be sent to the liquefaction unit (CL) as solvent.

10. The process according to claim 1, wherein a part of the medium and heavy fractions (medium and heavy distillates) obtained in the distillation or flash unit (D) is added to the feedstock containing coal to be sent to the liquefaction unit (CL) as solvent.

11. The process according to claim 1, wherein part of the solvent separated in the distillation step (RS) is added to the feedstock containing coal to be sent to the liquefaction unit (CL) as solvent.

12. The process according to claim 1, wherein in the distillation step (RS) of the liquid stream consisting of liquefied coal and the solvent used, a further stream is separated as distillate.
- 5 13. The process according to claim 12, wherein part of the further stream separated, as distillate, in the distillation step (RS) is added to the feedstock containing coal to be sent to the liquefaction unit (CL) as solvent.
- 10 14. The process according to claim 1, wherein the direct liquefaction of the stream containing coal is effected by mixing said stream with an aromatic solvent in a quantity ranging from 20 to 80% with respect to the coal, and with a suitable catalyst in dispersed phase,
15 operating at a temperature ranging from 360 to 440°C, a hydrogen pressure ranging from 3 to 30 MPa and with residence times lower than or equal to 4 h.
15. The process according to claim 1, wherein the extraction step with a solvent to remove the ashes is effected at a temperature ranging from 150 to 350°C and
20 a pressure ranging from 20 to 60 atm in the presence of a suitable aromatic solvent.
16. The process according to claim 1, wherein a heavy feedstock, selected from heavy crude oils, distillation residues, heavy oils coming from catalytic treat-
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ment, thermal tars, bitumens from oil sands, various types of coals and/or other high-boiling feedstocks of a hydrocarbon origin known as black oils, is added to the feedstock consisting of coal to be sent to the liquefaction unit (CL).

17. The process according to claim 1, wherein a heavy feedstock, selected from heavy crude oils, distillation residues, heavy oils coming from catalytic treatment, thermal tars, bitumens from oil sands, various types of coals and/or other high-boiling feedstocks of a hydrocarbon origin known as black oils, is added to the liquid stream consisting of liquefied coal to be sent to the hydro-treatment step (HT).

18. The process according to claim 1, wherein before being sent to one or more distillation or flash steps (D), the stream containing the hydro-treatment reaction product and the catalyst in dispersed phase, is subjected to a separation pre-step effected at high pressure in order to obtain a light fraction and a heavy fraction, said heavy fraction alone being sent to said distillation step(s) (D).

19. The process according to claim 18, wherein the light fraction obtained by means of the high pressure separation step is sent to a secondary post-treatment hydrogenating section producing a lighter fraction con-

containing C₁-C₄ gas and H₂S and a heavier fraction containing hydro-treated naphtha and gas oil.

20. The process according to claim 19, wherein the post-treatment hydrogenating reaction is effected at a pressure ranging from 7 to 14 MPa.

21. The process according to claim 1, wherein all the liquid stream substantially consisting of liquefied coal is mixed with a suitable hydrogenation catalyst and sent to the hydro-treatment reactor (HT), whereas at least 60% of the stream containing asphaltenes, which also contains catalyst in dispersed phase and possibly coke and is enriched with metals coming from the initial feedstock, is recycled to the hydro-treatment zone.

22. The process according to claim 21, wherein at least 80% of the stream containing asphaltenes is recycled to the hydro-treatment zone.

23. The process according to claim 1, wherein the liquid stream substantially consisting of liquefied coal and at least most of the stream containing asphaltenes, which also contains catalyst in dispersed phase and possibly coke, are mixed with a suitable hydrogenation catalyst and sent to the hydro-treatment reactor (HT).

24. The process according to claim 1, wherein part of the distillation residue (tar) or liquid leaving the flash

unit (D) is sent to the deasphalting zone (SDA) and at least part of the remaining part of said distillation or flash residue is sent to the hydro-treatment reactor.

- 5 25. The process according to claim 24, wherein at least part of the remaining quantity of the distillation or flash residue (D) is sent to the hydro-treatment reactor together with at least part of the stream containing asphaltenes coming from the deasphalting section
- 10 (SDA).
26. The process according to claim 1, wherein at least 80% by weight of the distillation residue is sent to the deasphalting zone (SDA).
27. The process according to claim 26, wherein at least
- 15 95% by weight of the distillation residue is sent to the deasphalting zone (SDA).
28. The process according to claim 1, wherein at least part of the remaining quantity of distillation residue (tar), not sent to the deasphalting zone is recycled
- 20 to the hydro-treatment section (HT).
29. The process according to claim 1, wherein the distillation steps are carried out at a reduced pressure ranging from 0.0001 to 0.5 MPa.
30. The process according to claim 29, wherein the distil-
- 25 lation steps are carried out at a reduced pressure

ranging from 0.001 to 0.3 MPa.

31. The process according to claim 1, wherein the hydro-treatment step is carried out at a temperature ranging from 370 to 480°C and at a pressure ranging from 3 to 30 MPa.

32. The process according to claim 31, wherein the hydro-treatment step is carried out at a temperature ranging from 380 to 440°C and at a pressure ranging from 10 to 20 MPa.

33. The process according to claim 1, wherein the deasphalting step is carried out at temperature ranging from 40 to 200°C and at a pressure ranging from 0.1 to 7 MPa.

34. The process according to claim 1, wherein the deasphalting solvent is a light paraffin with from 3 to 7 carbon atoms.

35. The process according to claim 1, wherein the deasphalting step (SDA) is carried out under subcritical or supercritical conditions with one or more steps.

36. The process according to claim 1, wherein the stream consisting of deasphalted oil (DAO) is fractionated by means of conventional distillation.

37. The process according to claim 1, wherein the stream consisting of deasphalted oil (DAO) is mixed with the

products separated in the distillation step after being condensed.

38. The process according to claim 1, wherein the hydrogenation catalyst derives from a decomposable precursor or a preformed compound based on one or more transition metals.

39. The process according to claim 37, wherein the transition metal is molybdenum.

40. The process according to claim 1, wherein the concentration of the catalyst in the hydroconversion reactor, defined on the basis of the concentration of the metal or metals present, ranges from 300 to 20,000 ppm.

41. The process according to claim 40, wherein the concentration of the catalyst in the hydroconversion reactor ranges from 1,000 to 10,000 ppm.

42. The process according to claim 1, wherein a fraction of the stream containing asphaltenes, coming from the deasphalting section (SDA), called flushing stream, is sent to a treatment section with a suitable solvent for the separation of the product into a solid fraction and a liquid fraction from which said solvent can be subsequently separated.

43. The process according to claim 42, wherein the flushing stream is in a quantity ranging from 0.5 to 10% by

volume with respect to the fresh feedstock.

44. The process according to claim 43, wherein at least part of the liquid fraction deriving from the treatment section of the flushing stream is sent as such or after being separated from the solvent and/or after the addition of a suitable fluxing agent to the Fuel Oil fraction.

45. The process according to claim 44, wherein at least part of the liquid fraction deriving from the treatment section of the flushing stream is recycled to the hydro-treatment reactor (HT) and/or at least part of the liquid fraction deriving from the treatment section of the flushing stream is recycled to the coal liquefaction unit (CL).

46. The process according to claim 42, wherein the solvent used in the treatment section of the flushing stream is an aromatic solvent or a mixture of gas oils produced in the process itself or available in refineries.

47. The process according to claim 46, wherein the aromatic solvent is toluene and/or a mixture of xylenes.

48. The process according to claim 40, wherein the volumetric ratio solvent/flushing stream varies from 1 to 10.

49. The process according to claim 48, wherein the volu-

metric ratio solvent/flushing stream varies from 1 to 5.

50. The process according to claim 49, wherein the volumetric ratio solvent/flushing stream varies from 1.5 to 3.5.

51. The process according to claims 42 and 38, wherein the solid fraction of the product treated is sent to a further selective recovery treatment step of the transition metal or metals contained in the hydrogenation catalyst.

52. The process according to claim 51, wherein the transition metal or metals recovered are recycled to the hydro-treatment reactor (HT).